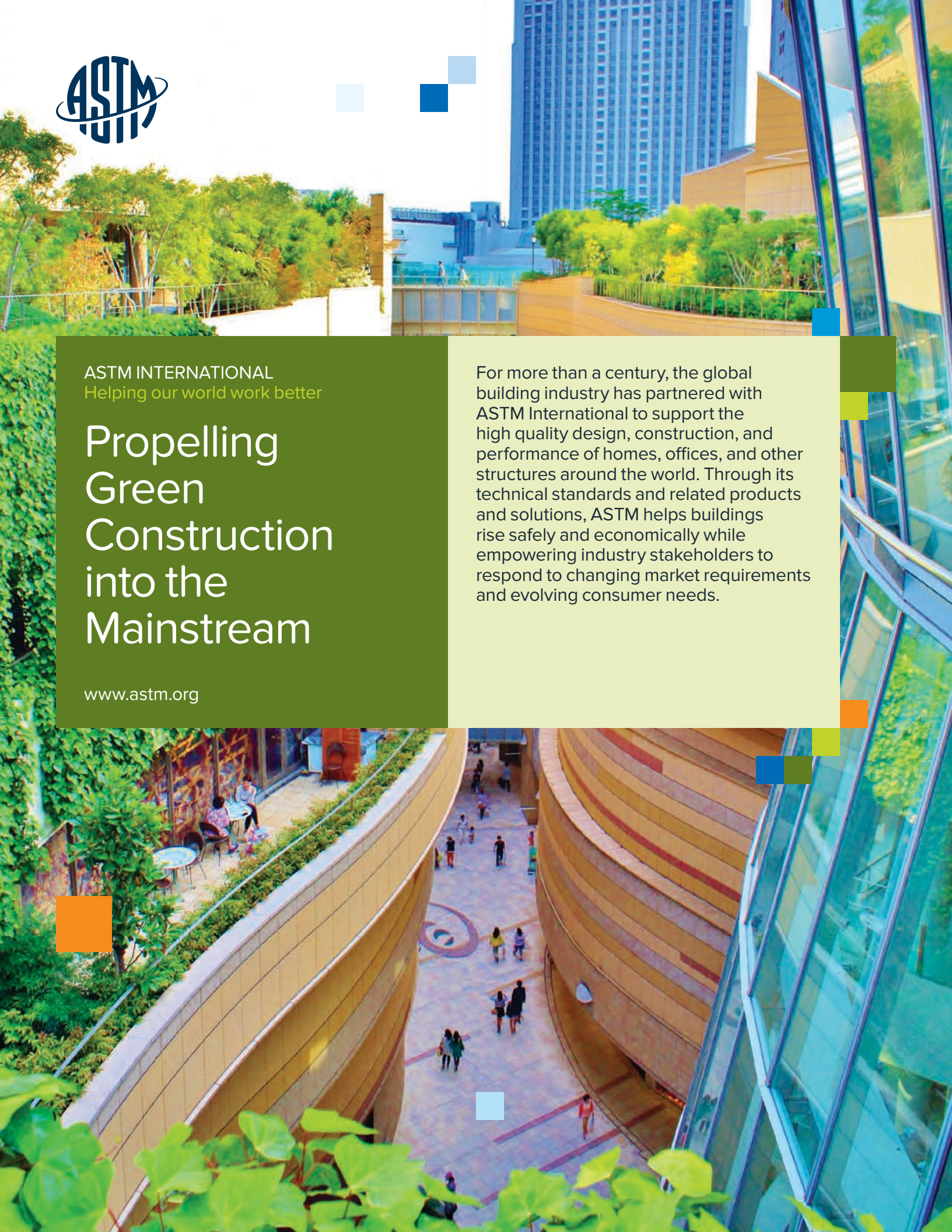


ASTM INTERNATIONAL
Helping our world work better

Propelling Green Construction into the Mainstream

www.astm.org

For more than a century, the global building industry has partnered with ASTM International to support the high quality design, construction, and performance of homes, offices, and other structures around the world. Through its technical standards and related products and solutions, ASTM helps buildings rise safely and economically while empowering industry stakeholders to respond to changing market requirements and evolving consumer needs.

Propelling Green Construction into the Mainstream

The worldwide building industry today has a growing demand for sustainable construction. Sustainable or "green" construction focuses on a more effective use of resources and ultimately the creation of healthier, more energy efficient and environmentally friendly buildings. The move toward sustainability is transforming the way the industry designs, constructs, and operates buildings. Evidence of this shift can be seen in green roofing systems atop city office buildings and solar panels on houses and commercial structures. According to studies, the green building materials market will continue to grow, and it could reach between $365 and $375+ billion by 2022.

As this momentum increases, standards and solutions from ASTM International will continue to help meet industry goals and contractor and consumer needs. Already, more than 200 standards support the design and construction of more sustainable buildings.

Standards: Technical Foundation of Codes and Rating Systems

Standards impact the growth of sustainable buildings through rating and certification programs. These programs help stakeholders navigate the often complex field of sustainability, defining green building attributes and guiding environmentally responsive practices.

One such program is the International Green Construction Code (IgCC), launched to foster sustainable building practices globally. Developed by the International Code Council, the IgCC is the first model code to include sustainability measures for construction projects and sites from design through construction, certificate of occupancy, and beyond. For both new and existing buildings, the IgCC provides code language for energy conservation, water efficiency, site impacts, building waste, material resource efficiency, and more.

200+

ASTM standards make a valuable contribution throughout all areas of the sustainable built environment.

ASTM International is one of five sponsors of the IgCC. The latest IgCC version cites more than 40 ASTM standards on various aspects of building construction, including green roof systems (E2399), solar reflectance (C1549), and water conservation in buildings (E2635). Standards from more than a dozen ASTM technical committees and on topics ranging from air quality to thermal insulation are referenced in the IgCC.

ASTM standards also help establish performance criteria for LEED (Leadership in Energy and Environmental Design), a globally recognized certification system. Architects, contractors, material suppliers, realtors, and facility managers rely on LEED to design, construct, and operate commercial buildings, houses, schools, and more. LEED addresses the entire building life cycle and recognizes best-in-class building strategies; it also provides third-party verification for green buildings. Every day, more than 160 000 m^2 or 1.7 million square feet of area is certified using LEED.

E60: Leading the Way in Sustainability Standards

ASTM's committee on sustainability (E60) develops standards that promote sustainability and sustainable development. Its standards for the built environment come from its subcommittee on buildings and construction (E60.01). The subcommittee established common language on sustainability in building performance with a standard (E2114) that promotes more effective communications among industry stakeholders. Another standard defines the three principles of sustainability — environmental, economic, and social — and the core approaches to decision making used in pursuing sustainability (E2432).

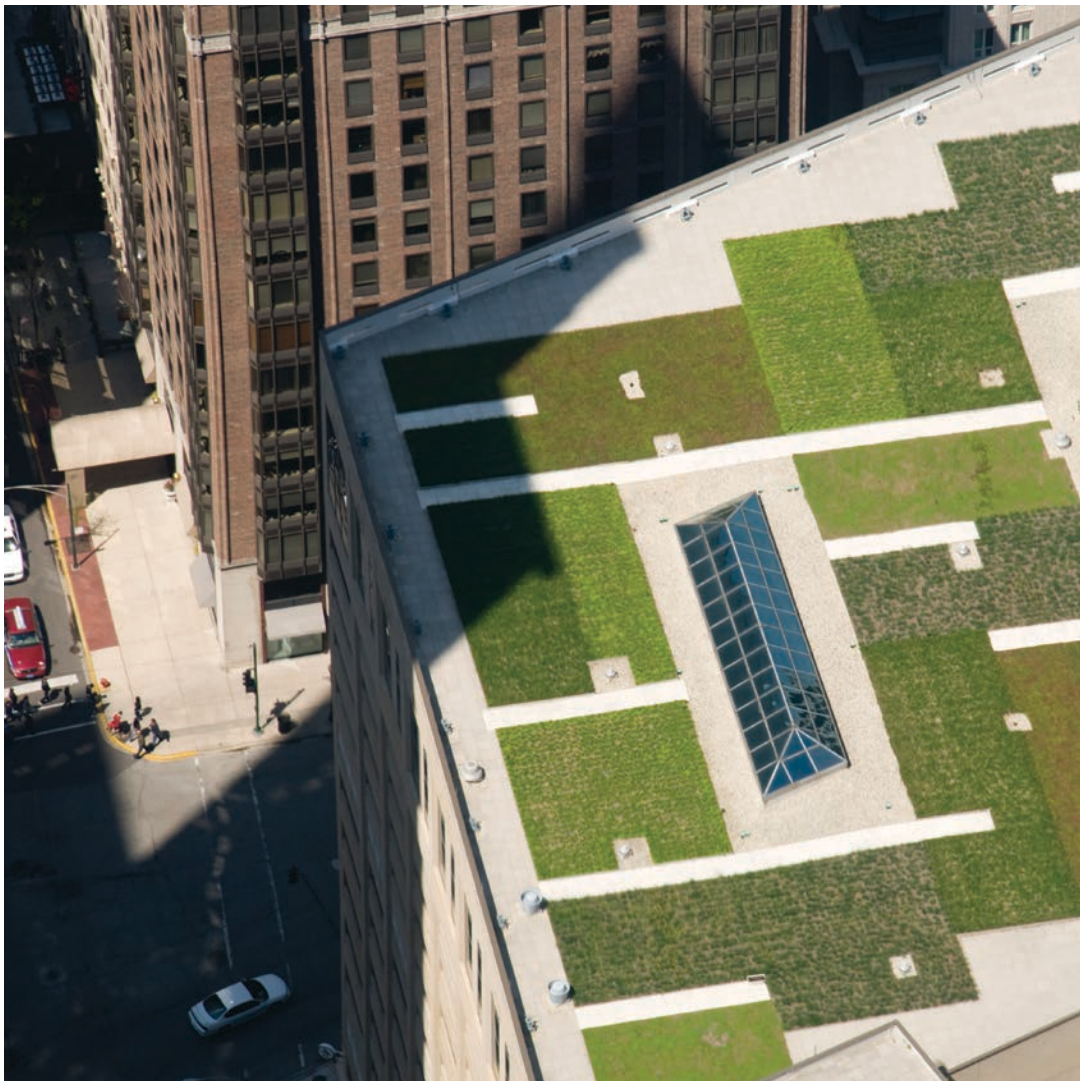
Subcommittee E60.01 also addresses the selection of building products in another standard. The standard covers collecting data to help evaluate the sustainability of commercial and residential building products (E2129).

Advancing Sustainability in Roofing

Another ASTM subcommittee (D08.24), part of ASTM's committee on roofing and waterproofing (D08), focuses on standards to advance more sustainable roofs.

Green roofing is a dynamic aspect of sustainable construction. A green roof, or rooftop garden, is vegetation grown to:

– Provide shade and remove heat from the air;



Progress

The development and installation of sustainable roofing systems is increasing on a wide range of buildings.

- Reduce the temperature of the roof surface and the surrounding air;
- Reduce air pollution and greenhouse gas emissions;
- Enhance stormwater management and water quality; and
- Improve building aesthetics.

Green roof designs fall into two general categories: extensive vegetative green roofs with drought-tolerant plants such as sedums and intensive vegetative green roofs with complete landscape gardens. In both approaches, green roofs help meet sustainable construction goals.

Design, material selection, installation, and maintenance are all part of using a green roof system. D08.24 has helped meet the growing need for guidance in this industry with standards for structural design, water permeability, system performance, irrigation requirements, plant and related material selection, and more. For example, E2399 on green roof systems provides designers with a method for replicating field conditions on green roofs and evaluating performance before construction.

Choosing plants is also crucial to a successful green roof system because rooftops often have strong and variable wind patterns and little protection from the sun's heat and ultraviolet radiation. One standard offers guidance on choosing, installing, and maintaining plants (E2400) for green roofs. Another standard guides in selecting membranes for vegetative roofing systems (D8014).

Overall, standards have helped bring down early adopter costs, spurring the use of green roofs on a global scale. As a result, relevant standards have been developed, including one with a comprehensive approach to designing, planning, and installing vegetative green roofs (E2777). The standard encourages innovative and responsible green roof design with a focus on performance and quality assurance.

Additional standards for sustainable roofing systems are underway in D08.24, including additional guides for membranes used in green roofs.

Cooler Roofs with D08 Standards

Another important green construction area is "cool" roofs, an approach for roofs to reflect heat and radiation back into the atmosphere. When less heat is absorbed

Cool Roofs

reflect heat and radiation back into the atmosphere.

into a building's interior, occupants benefit from lower air-conditioning energy use and a more controllable and consistent indoor environment. An array of cool roof materials helps mitigate the sun's effects, including asphalt shingles, metal, reflective coatings, roofing membranes, and roofing tiles.

Cool roof techniques can be used in low slope roofs (which have relatively flat rooflines and are installed atop institutional, commercial, industrial, office, retail, and multifamily buildings) and steep slope roofs (which have an inclined roofline and are generally used on single family homes). Two standards from the subcommittee on nonbituminous organic roof coverings (D08.18) play a valuable role in cool roof installation. Standards on solar reflectance (E1918) and calculating solar reflectance index (E1980) help building designers and consumers choose suitable cool roof materials.

Solar Energy: Powering Green Buildings

Buildings with rooftop solar arrays have become increasingly common. According to global consultancy McKinsey & Company, technological leaps and increased solar panel production have driven down costs. The technology — first used to power satellites and telescopes — is now used in homes; office buildings, warehouses, and other commercial structures; and solar farms covering acres of land.

For residential and commercial building owners, solar power leads to lower utility bills, independence from the traditional power grid, and a reduced carbon footprint. Growing demand is driving green builders to incorporate solar arrays in design and construction projects. Supporting these efforts are standards developed by the committee on solar, geothermal, and other alternative energy sources (E44). E44 standards touch on a wide range of clean energy applications. For example, one standard guides photovoltaic array installation on steep-sloped roofs (E2766).

In addition, glass, coatings, films, and optical component manufacturers rely on E903 to evaluate the solar absorptance, reflectance, and transmittance of their products. The standard helps with product development, optimization, and performance.

Supporting Green Building Materials

A green home is more than the sum of its parts — it also reflects its environmental impact. Green builders pay attention to all the details that come into play during a building's life cycle, including where it is built, the resources it consumes, how it affects the environment, and what materials go into its construction. Negative environmental impact can be minimized by using and applying green materials. Products containing a high percentage of rapidly renewable resources have a lighter environmental footprint and are promoted in the LEED rating system. Material durability is also an important consideration, helping to reduce life cycle costs and any negative impact.

Numerous committees drive the development of standards for high quality, environmentally friendly materials that support green construction. One group is the subcommittee on geotechnics of sustainable construction (D18.14, part of the committee on soil and rock, D18). D18.14 standards cover the use of industrial byproducts with earth materials in sustainable construction. Among these is a standard for tire-derived aggregates (TDA) (D7760), a construction material produced from recycled tires. TDA can be used instead of stone aggregate in many construction applications, including lightweight backfill behind building foundations and retaining walls. D7760 also supports the testing of hydraulic conductivity, which is required in TDA for civil engineering applications.

D7762 on self-cementing fly ash guides the use of coal fly ash in stabilizing soils. This helps limit fill settlement below buildings. Similarly, D7765 covers methods and recommendations on reusing green foundry sands — discarded by the foundry industry — in embankment and structural fill applications.

Another group that supports the development of green building materials is the subcommittee on plastic lumber (D20.20), part of the committee on plastics (D20). The subcommittee's work helps advance the use of plastic lumber products in boardwalks, decks, railings, bridges, and more. As an alternative for treated lumber, plastic lumber products resist insects, rot, moisture, and many chemicals. These products are composites made from a mix of plastics and fibers to enhance strength. Typically, plastic composites products benefit the environment by using recycled plastics and reducing waste.

Plastic lumber standards include property tests that indicate how the material will perform in conditions similar to the targeted construction setting, aiding quality control and material selection. Other standards specify products, including structural grade plastic lumber (D7568) and polymeric piles (D7258). Another notable standard is D6662 on polyolefin-based plastic lumber, which covers products made from recycled polyolefin plastics for use outdoors. Codes now have recognized the usefulness of plastic composites in decking and similar applications and are regulating them based on D6662 and D7032 (a standard from the committee on wood, D07).

Standards from D07 also support the development of green construction materials. Among these are the standards on structural composite lumber products (D5456) and on air and emission rates from wood products (E1333), both of which are referenced in

E903 on solar absorptance, reflectance, and transmittance of materials
Manufacturers rely on E903 to evaluate their products. The standard helps with product development, optimization, and performance.

the IgCC. E1333 covers a test for the emission of formaldehyde (a colorless, pungent chemical used in manufacturing) so that building occupants can be protected from the potentially negative health effects of overexposure to this gas.

Standards also help develop products and systems that make buildings more energy efficient, reduce utility costs, and increase occupant comfort. For example, one standard supports the use of insulated vinyl siding, which reduces heat loss (D7793). In addition, the committee on thermal insulation (C16) supports cellulose insulation, an efficient, nontoxic, and affordable product made from post-consumer recycled newsprint, paper, and cardboard. Cellulose is attractive for green construction projects because of its airtightness, which supports greater heating and cooling efficiency; it also resists mold and retards fire.

A Growing Demand

For home and commercial facility owners, solar offers a clean energy source that leads to lower utility bills, independence from the traditional power grid, and a reduced carbon footprint.

In particular, the standard on cellulosic fiber thermal insulation (C739) helps manufacturers deliver the highest quality cellulose insulation products. C739 covers the composition and physical requirements of chemically treated, recycled cellulosic fiber loose-fill insulation for attics and enclosed building spaces. Manufacturers can use another standard to determine insulation resistance to fungal growth under high humidity (C1338).

In addition, the ASTM committee on concrete and concrete aggregates (C09) has developed standards for reusing materials. One standard supports reusing industrial materials in concrete (C618). Similarly, another covers the reuse of ground granulated blast-furnace slag cement in concrete and mortars (C989). Other standards also support more sustainable construction practices. One allows for recycled aggregates (C33); another for the use of recycled water (C1602); a third for returned concrete (C1798); and a fourth for both recycled water and returned concrete (C94).

To reduce roofing waste and reuse scrap, a standard provides guidance on establishing a recycling program (D8013). Further, a standard is underway in the committee on soil and rock (D18) to guide the use of scrap and waste shingle in roadway applications.

Better Water Management with ASTM Standards

Another important factor in sustainable construction is water management. The subcommittee on water use and conservation (E60.07) has developed standards for water conservation in buildings (E2635) and water stewardship in building design, construction, and operation (E2728).

Stormwater management is also taken into account with sustainable construction. Impervious surfaces such as driveways, sidewalks, and parking lots are susceptible to large amounts of stormwater runoff, which can have harmful environmental impacts: increased pollution, frequent flooding, stream channel instability, flow onto adjacent properties, and damage to transportation and utility infrastructure.

Through the subcommittee on precast concrete products for stormwater management (C27.70), three standard tests support separators and underground settling devices, and filtration. One standard helps describe device performance in a wide range of conditions (C1745). Another gives the means to measure how well separators and settling devices remove sediment from stormwater (C1746). A third helps determine how stormwater filters perform in varying stormwater flows (C1814).

To address these challenges, green building developers are turning to pervious concrete. Pervious concrete captures stormwater and allows it to seep into the ground, reducing runoff and helping to meet stormwater regulations from bodies such as the U.S. Environmental Protection Agency. By eliminating untreated stormwater runoff, pervious concrete advances sustainable development goals by:

- Reducing pollution;
- Protecting streams, watersheds, and ecosystems;
- Reducing surface temperatures and heat island effects; and
- Eliminating the need for expensive collection and detention systems.

The LEED rating system on the performance of sustainable buildings recognizes pervious concrete when it is used for stormwater management.

Pervious concrete cannot be tested using traditional concrete standards because of its porosity. That's why a standard was developed to help verify that freshly mixed pervious concrete delivered to a project corresponds to the producer's mix proportions (C1688). Also, C1701 on in-place pervious concrete is used to detect infiltration rate reduction, identifying any need for remediation.

The subcommittee on precast concrete products for stormwater management (C27.70, part of the committee on precast concrete products, C27) also supports this field. Regulatory agencies and testing laboratories use ASTM standards aimed at reducing water pollution and controlling erosion. For example, one testing protocol covers stormwater hydrodynamic systems (C1746), which are used to remove solids that could cause contamination from stormwater runoff.

Pervious surfaces
Pervious concrete advances sustainable development goals by mitigating pollution; protecting streams, watersheds, and ecosystems; reducing surface temperatures and heat island effects; and eliminating the need for expensive collection and detention systems.

Establishing Sustainability with EPDs

Along with the global growth in sustainable building construction has come a rise in "green" product claims from material manufacturers and other industry suppliers. Understanding the meaning and validity of these claims, whether they are based on certification programs or individual company assertions, is becoming increasingly difficult.

To best determine product sustainability, building designers, contractors, consumers, and code officials need credible information on environmental impact to make more informed choices. Manufacturers also benefit by tapping into the growing market for green building materials and through greater awareness of how their products and practices affect the environment. A key tool available to help manufacturers assess the true greenness of their products is the environmental product declaration (EPD), a detailed report about a product's effect on the environment over the course of its lifetime.

In 2012, ASTM International became a Program Operator for developing product category rules (PCRs) and verifying EPDs in response to the growing need to understand the real environmental impact of products from raw material extraction to disposal and recycling (www.astm.org/EPDs). PCRs detail the rules and guidelines for developing environmental declarations for products that can fill equivalent functions. EPDs are verified in accordance with the International Organization for Standardization (ISO) 14025 standard and to ensure that life cycle assessment data accurately describes the environmental aspects of a product. ASTM technical advisory committees provide specific industry knowledge to the development process.

ASTM has helped many industries in developing PCRs and verifying new EPDs, making sure that all proper procedures are followed. Industry-specific efforts have led to published PCR with the following organizations:

- Asphalt Roofing Manufacturers Association
- Canadian Precast/Prestressed Concrete Institute
- Expanded Shale, Clay, and Slate Institute
- Gypsum Association
- Interlocking Concrete Pavement Institute
- National Concrete Masonry Association
- National Precast Concrete Association
- Portland Cement Association
- Precast/Prestressed Concrete Institute
- Single Ply Roofing Industry
- Slag Cement Association
- Window and Door Manufacturers Association

High Performance Buildings

Today's high performing green buildings share a common characteristic: They do more with less. High performing buildings have smaller ecological footprints and create a healthy indoor environment for the user; they meet occupants' functional and aesthetic needs while scoring gains in energy efficiency, material use and sourcing, water efficiency, carbon footprint,

Efficient

Pervious concrete advances sustainable development; ASTM standards support the use of this material.

construction practices, and indoor air quality. Some "net-zero" homes, built on the cutting edge of sustainable development, are so efficient that they generate much of their own energy.

Helping green construction stakeholders to fulfill their vision for high performing homes and buildings are standards from the committee on performance of buildings (E06). The committee addresses the overall performance, improvement, and management of buildings and related facilities. Relevant E06 standards include a specification for flat insulating concrete forms (E2634) developed by the E06 subcommittee on serviceability. This standard focuses on the use of ICF systems as energy-efficient building envelopes for both residential and commercial construction.

Airtightness and windtightness are core components in sustainable building design and construction. Controlling air leakage — unwanted flow of air through the external fabric of the building envelope — is central to energy efficiency and unnecessary heat loss. In addition, heat that escapes from buildings carries a significant amount of moisture. This can lead to damage to buildings and building materials, and may have a severe effect on the air quality of the living space.

Two E06 standards that help green building stakeholders test and quantify the airtightness of a building envelope address air leakage rate (E779) and airtightness of buildings (E1827). In addition, another method helps assess air leakage through exterior windows, curtain walls, and doors (E283). A companion standard on water penetration outlines the procedures for testing the water resistance of installed exterior windows, skylights, doors, and curtain walls (E1105).

And an additional standard, one of a planned series, provides guidance for hygrothermal modeling for building envelope moisture control design (E3054). The guide helps with predicting and evaluating design considerations.

Standards from the committee on environmental assessment, risk management, and corrective action (E50) also help in assessing building performance. A standard on building energy performance (E2797) describes how to conduct a building energy performance assessment for commercial real estate transactions. An additional proposed standard will describe how to evaluate building energy performance, including energy consumption and benchmarking energy consumption against similar buildings.

High performance green buildings are also defined by their ability to offer high quality indoor air. This is achieved through ventilation systems that bring in fresh air without losing heat during winter or coolness during summer, control the source of pollutants, and provide predictable and consistent levels of thermal comfort. Air quality in the residential environment is the focus of the indoor air subcommittee, a part of the committee on air quality (D22). Among the group's standards is a guide on indoor air quality and ventilation (D6245). This standard details the use of continuous monitoring of indoor and outdoor carbon dioxide concentrations as a guide for evaluating building ventilation and indoor air quality.

ASTM Standards for Sustainability in Building

Many standards discussed in this overview are included in *ASTM Standards for Sustainability in Building* (www.astm.org/SUSTAINBLDGCMP), an online compilation of 225 ASTM standards. This resource is relevant to almost any green rating system or code that users may come across in the marketplace.

Responsive

Standards help stakeholders fulfill their vision for high performing buildings.

Sustainability Standards Development

A comprehensive database references over 850 standards and programs from ASTM and other organizations involved in sustainability. For the standards and ASTM's sustainability overview, go to www.astm.org/sustainability.

ASTM *Standardization News* Information

Articles and other content on sustainability and construction topics are available from ASTM's *Standardization News* magazine at www.astm.org/sn-construction and www.astm.org/sn-environmental.

Purchasing ASTM Standards

More than 12,000+ ASTM standards are used worldwide to improve product quality, enhance safety, and facilitate trade. You can purchase individual standards; a volume that groups like standards together; a section that is comprised of several volumes covering an industry segment; or the entire collection. Print and online subscriptions are available. To browse ASTM standards, adjuncts, and collections, and to learn more about purchasing options, visit www.astm.org/standard.

The ASTM technical committees highlighted in this piece include:

- Air Quality (D22)
- Concrete and Concrete Aggregates (C09)
- Environmental Assessment, Risk Management, and Corrective Action (E50)
- Performance of Buildings (E06)
- Plastics (D20)
- Precast Concrete Products (C27)
- Roofing and Waterproofing (D08)
- Soil and Rock (D18)
- Solar, Geothermal, and Other Alternative Energy Sources (E44)
- Sustainability (E60)
- Thermal Insulation (C16)
- Wood (D07)

Additional ASTM technical committees involved in the field of building construction include:

- Adhesives (D14)
- Building and Environmental Acoustics (E33)
- Building Seals and Sealants (C24)
- Cement (D01)
- Fire Standards (E05)
- Geosynthetics (D35)
- Glass and Glass Products (C14)
- Gypsum and Related Building Materials and Systems (C11)
- Plastic Piping Systems (F17)
- Resilient Floor Coverings (F06)
- Steel, Stainless Steel, and Related Alloys (A01)
- Road and Paving Materials (D04)
- Weathering and Durability (G03)

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Committed to serving global societal needs, ASTM International positively impacts public health and safety, consumer confidence, and overall quality of life. We integrate consensus standards, developed with our international membership of volunteer technical experts, and innovative services to improve lives — Helping our world work better.

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